Injury Extra 45 (2014) 1–5

Contents lists available at ScienceDirect

Injury Extra

journal homepage: www.elsevier.com/locate/inext

Case report

Posterior sternoclavicular epiphyseal fracture-dislocation: Case report and review of literature

Alan Perdreau *, Benoit Bingen, Louis Gossing, Étienne Lejeune, Alain Beugnies

Department of Orthopaedic Surgery, Clinic Saint-Luc, Bouge (Namur), Belgium

ARTICLE INFO

Article history:
Accepted 11 October 2013

Keywords:
Posterior sternoclavicular dislocations
Epiphyseal injuries
Child
CT scan
Radiographs

ABSTRACT

Posteriorly displaced physeal fractures of the medial clavicle are relatively rare injuries in the growing skeleton and are often confused with the posterior dislocations of the sternoclavicular joint (SCJ). Frequently, these initially undiagnosed due to variable clinical presentation and inadequate visualisation of the joint on plain radiographs. This failure of diagnosis or delayed treatment may lead to serious complications though secondary injuries of mediastinal structures.

We present a case report of a 16-year-old male with posterior sternoclavicular epiphyseal fracture-dislocation without vasculonervous injury that occurred in basketball training. The correct diagnosis required multiple modalities over two emergency department visits. Computed tomography with intravenous contrast was the imaging modality of choice for diagnosis. Treatment consisted of attempts at closed reduction, which was not successful. Open reduction was performed with relocation of the clavicle into the periosteal sleeve followed by strong suture material. We have reviewed the literature to provide an insight with regards to correct diagnosis and management of this injury.

1. Introduction

Posterior sternoclavicular dislocation (PSCD) is an uncommon injury that occurs generally during high-energy trauma [1,2] or sporting activities [3–13]. On account of late closure of the medial clavicular epiphysis, posterior epiphyseal disruption must be taken into consideration in every patient younger than 25 years [3–5,8,9,14–18]. While true PSCD can occur in skeletally immature patients [8,19], the majority of the injuries are posteriorly displaced fracture of the medial clavicular physis [16,18,20–22]. Often these injuries go unrecognised at the time of presentation due to their relative infrequency, paucity of physical examination findings, and difficulty in interpreting plain radiographs [2,5,6,8,10,11,16,18,23,24]. This failure of diagnosis or delayed treatment may lead to serious complications though secondary injuries of mediastinal structures [2,3,8,23,25–34]. We present a rare case of posterior sternoclavicular epiphyseal fracture-dislocation that occurred in a young basketball player, which was not recognised at his initial presentation in emergency department. The purpose of this article is to share our experience and to review the literature with regards to correct diagnosis and management of this injury.

2. Case

A 16-year-old right hand-dominant boy was admitted in our emergency department with a shoulder injury during basketball training. After attempting to block a shot, he fell onto his right posterolateral shoulder.

He described immediate pain in his shoulder and inability to move it without significant anterior chest discomfort. He denied any paresthesia, weakness, dyspnoea, dysphagia, or dysphonia.

His initial vital signs were: temperature 36.7 °C, heart rate 48 breaths/min, blood pressure 133/67 mmHg and respiratory rate 16 breaths/min. On physical examination, he presented with severe shoulder pain, holding his arm in an internally rotated and adduction position. There was no palpable deformity over the shoulder but tenderness was localised at the distal sternocleidomastoid muscle. He could externally and internally rotate his arm but could not tolerate minimal passive abduction of the shoulder. His neurovascular examination result of the distal extremity was normal.

A 3-view shoulder X-ray was ordered (Fig. 1) and revealed no bony injuries or articular dislocations.

The patient was discharged in a broad-arm sling with a diagnosis of shoulder sprain and sternocleidomastoid muscle haematoma. He was referred to the orthopaedics clinic in one week.

He returned to the same emergency department 48 h later complaining of persistent right shoulder pain. On examination, he had tenderness to palpation over the medial end of his right clavicle. When viewed from the side, the right sternoclavicular

* Corresponding author at: Department of Orthopaedic Surgery, Clinic Saint-Luc Clinique St Luc, rue St Luc 8, 5004 Bouge, Belgium. Tel.: +32 42257007.
E-mail address: perdreaua@icloud.com (A. Perdreau).

1572-3461 © 2013 Published by Elsevier Ltd. Open access under the Elsevier OA license.
http://dx.doi.org/10.1016/j.injury.2013.10.035

Fig. 1. Anteroposterior radiograph of the right shoulder from the first admission.

Fig. 2. Anteroposterior radiograph of the right clavicle. Note the markedly displaced medial end of clavicle (arrow) compared to the sternum (S).

joint (SCJ) was swelling and less prominent than the contralateral side, giving rise to the suspicion of PSCD.

Plain radiographs of the right clavicle (Fig. 2) revealed a slight superior displacement of the medial end suggesting a sternoclavicular dislocation.

CT scan of the upper chest with intravenous contrast confirmed posterior displacement of the medial end of the right clavicle with an epiphyseal fracture. Meticulous attention revealed, a small bony fragment just anterior to the medial right clavicular end corresponding to avulsed fragment of metaphysis attached to the undisplaced anterior periosteum (Fig. 3A and B). There was no evidence of secondary injuries of the mediastinal structures however clavicular head abutted but did not penetrate the brachiocephalic artery (Fig. 4A and B).

After obtaining parental informed consent, the patient was taken to operating room for reduction under general anaesthesia with a thoracic surgeon on standby notification.

In first time, closed reduction technique was attempted with the patient in supine position with a sandbag placed between the scapulae. Longitudinal traction was applied to the right arm against countertraction in an abducted and slightly extended position, and the medial end of the clavicle was pulled in the anterior direction manually. Combined manoeuvres could not affect a reduction and open procedure was realised in a second time.

A transverse incision centred over the SCJ was used. The dissection was carried out through the plastysma to the level of the periosteum. Periosteal elevation was performed in a lateral to medial direction over the clavicle, carefully exposing the medial end of the clavicle and SCJ. With this exposure, posterior epiphyseal disruption of the medial clavicle with metaphyseal fragment (Salter-Harris type II injury) was clearly identified. The clavicle had not adhered to the great vessels, and the reduction was performed without complications using a towel clip. The stabilisation was obtained using No.1 polyester suture passed from the manubrium/epiphyseal piece into the medial clavicle through bone tunnels. The periosteal sleeve was then repair with

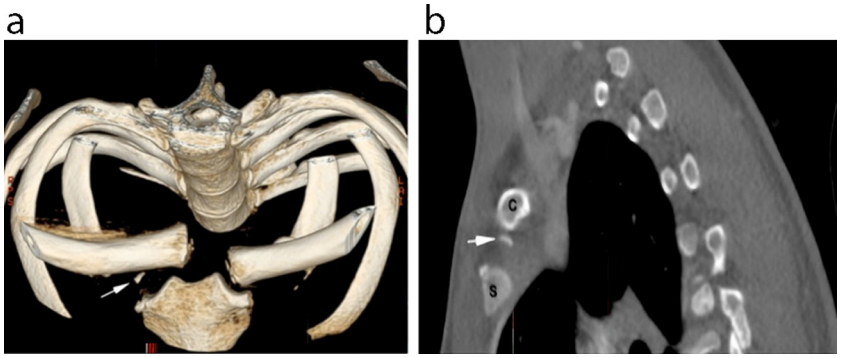

Fig. 3. (A) Three-dimensional computer tomographic reconstruction showing complete posterior dislocation of right sternoclavicular joint with evidence of a tiny bony fragment (arrow) near the clavicle head suggesting an epiphyseal fracture. (B) Sagittal view of superior chest computed tomography (CT) scan showing posteriorly displacement of the right clavicle (C) with metaphyseal fragment (arrow). Also shown is the sternum (S).

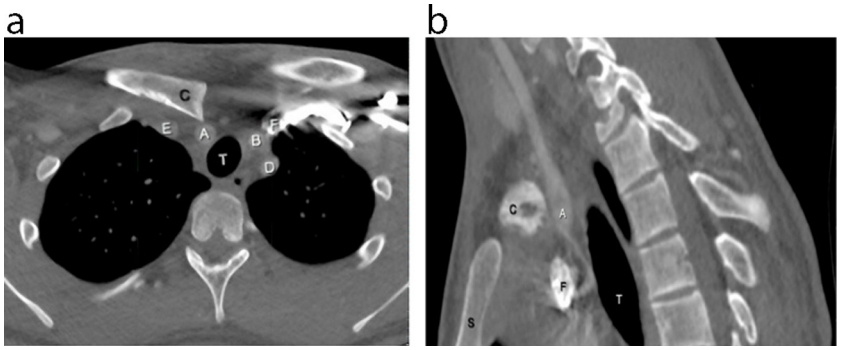

Fig. 4. (A) Axial view of the superior chest CT scan showing medial clavicle (C) abutting the brachiocephalic artery (A). Also are shown the trachea (T), left common carotid artery (B), left subclavian artery (D), right and left brachiocephalic vein (E and F). (B) Sagittal view of superior chest CT scan showing the medial end of the right clavicle (C) in contact with the brachiocephalic artery (A). Are also represented the trachea (T), sternum (S) and the left brachiocephalic vein (F).

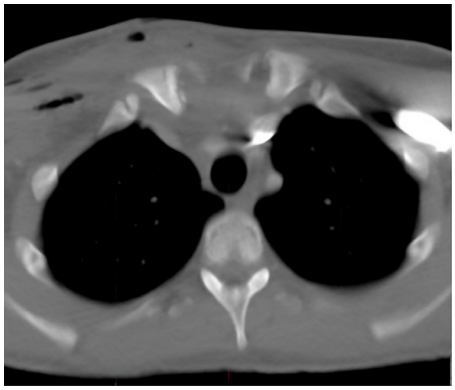

Fig. 5. Axial view of the superior chest CT scan on day 2 after surgery showed a complete reduction of the epiphyseal fracture.

polyglactic acid suture and the physical fracture was further stabilised with costoclavicular ligament repair, which has been secured by costoclavicular cerclage in PDF. Stability was subsequently tested with gentle ranging of the upper extremity and loading of the SCJ.

Postoperatively, the patient had a repeat CT scan to confirm the reduction of the lesion and the normal anatomy of the mediastinal structures (Fig. 5).

The patient was discharged home on the third postoperative day with figure-of-eight splint to be worn for a total of 4 weeks. After this time, sling immobilisation was continued for an additional 2 weeks, with initiation of physical therapy for gentle passive and active range-of-motion exercises. Patient was permitted to return to sports, 3 months postoperatively.

3. Discussion

3.1. History

The first case of PSCD was described by Sir Cooper [35] in 1824, and subsequently by various authors in the form of case reports and short series of cases [2,5,7,8,21]. Though there have been numerous cases on this injury in adults, little has been published on PSCD or posterior sternoclavicular epiphysea fracture-dislocation in children and adolescents [2,4–6,9,14,16,18,21,27,36–38].

3.2. Anatomy

Anatomically, the SCJ is a diarthrodial joint with a saddle shape that link the upper extremity to the thorax. Less than half of the medial clavicle articulates with the sternum, making it unstable and the most incongruous joint in the body. However, the stability is supported by a disc, a fibrous capsule anteriorly and posteriorly, and by the anterior and posterior sternoclavicular, interclavicular and costoclavicular ligaments [36,39]. The posterior ligaments are significantly stiffer and a 50% greater force is required for a posterior, than an anterior dislocation [33]. This is explained, in part, why the anterior dislocation is seen much more frequently, with a 20:1 ratio [40].

In children or young adults, the medial clavicle epiphysis is the last epiphyseal centre to appear and the last to fuse. Generally, it ossifies around 18–20 years of age, and fuses to the clavicle metaphysis around 23–25 years [38,41,42]. It is well known that up until the time of fusion, the growth plate is the weakest part of joint and is more commonly injured than ligamentous structures. For this reason, children and young adults will typically demonstrate the Salter-Harris type I or II fracture while adults with completed skeletal maturation will characteristically present with a true sternoclavicular dislocation [18]. There are no clinical sign to distinguish one condition to the other, and radiographic diagnosis is often difficult as well. The correct diagnosis is made during open reduction or suspected after detailed analysis of the CT scan [14,18,22,43,44]. This is why many of the reports do not make a clear distinction between these two injuries, especially when managed nonoperatively.

3.3. Frequency

Dislocations and epiphyseal fractures to the SCJ are uncommon injuries making up 1.2–4% of shoulder injuries [14,45,46]. PSCD make up <1% of all dislocations [2,37]. Less than 1% of children's fractures involve the medial end of the clavicle [18,41].

3.4. Mechanisms of injury

Sternoclavicular injury with posterior displacement is seen most commonly in high-energy trauma such as motor vehicle accidents [1,2] but has been reported in sporting activities with contact [2–12,38]. As in this case, the mechanism is often a posterolateral injury to the shoulder, causing a lever mechanism to the medial clavicular head, forcing displacement posterior to the sternum [38,41,47]. A direct anterior-to-posterior force to the medial clavicle is less frequently responsible for posterior dislocation [2,3,36]. Atraumatic dislocations are rare; however three cases of spontaneous posterior dislocation have been reported in the literature in patients with generalised laxity [48–51].

3.5. Clinical findings

Clinical diagnosis is often missed because of diffuse pain and as swelling of overlying tissue hides the deformity. Pain radiates laterally to the shoulder and up to the neck and is made worse with shoulder movement. The sternoclavicular area is usually tender to palpation but gap is often subtle and may remain unrecognised [5,6,10,14,16,18,52]. Sometimes, a posterior displacement is misdiagnosed as an anterior displacement with prominent anterior swelling [41]. Other clinical findings include the shoulder being held forward while the ipsilateral elbow supported by the opposite hand and the head bent towards the affected side in an attempt to lessen pain [6,7,53,54].

3.6. Diagnostic imaging

PSCD and posterior sternoclavicular epiphyseal fracture-dislocation are commonly difficult to assess with standard plain film studies [9]. Anteroposterior radiographs are of limited utility because the clavicle dislocates perpendicular to the plain of the film and superimposed ribs or mediastinal structures obscure the SCJ. Asymmetry between the medial ends of the clavicle seen at the standard chest radiogram usually indicates a sternoclavicular dislocation, although this may not be well visualised in subtle dislocations [2,55].

Rockwood or Serendipity view [14,21], Hobbs view [56,57] and Heinig's projection are the specific plain radiograms for evaluating the SCJ dislocation [18,20] and may aid to the diagnosis. However such specialised views can be difficult to perform reliably and are not to be widely practised.

CT scan are the most appropriate imaging method to confirm the diagnosis and evaluating the mediastinal structures and should be used whenever there is a suspicion about SCJ dislocation. Frequently on the CT scan the clavicular metaphyseal displacement is misinterpreted as sternoclavicular dislocation because clavicular epiphysis is not ossified. However, meticulous attention

can reveal bony fragments anterior to the posteriorly dislocated clavicle [2,4,9,18,52] or callus formation [18] perfectly consistent with epiphyseal fracture, but not with dislocation. In the event of suspected vascular injury, intravenous contrast may be uses to enhanced CT interpretation.

Ultrasound has also been described to be of benefit both in the diagnosis of injury at the bedside [24] and in judging the adequacy of closed reductions [24].

Magnetic resonance imaging (MRI) can assess for neurovascular injuries if symptoms are present after reduction. An other advantage of the MRI, is the visualisation of epiphysis and the growth plate integrity [16].

4. Complications

The repercussions for missed or delayed diagnoses of posterior displacement of the medial end of the clavicle can have significant complications, due to the effects on the vital structures that are in close proximity: the trachea, oesophagus, lungs, great vessels, and brachial plexus. About 30% of patients with posterior-directed medial clavicle injuries will have concomitant thoracic injuries [26,58–60]. These injuries resulting from the acute trauma or from continued pressure of the medial clavicle on the retrosternal structures include airway compromise [5,29,30,58], tracheosophageal fistula [27], pneumothorax [32], compression or dilacerations of great vessels [3,7,8,23,25,26,31], brachial plexus lesions and thoracic outlet syndrome [27,28,34,44].

5. Management

Some authors have proposed that the medial clavicular physeal fractures may remodel with the time and therefore do not require closed or open reduction [41].

Traditionally, closed reduction is the treatment of choice in the acute PSCD and posterior sternoclavicular epiphyseal fracture-dislocation without any mediastinal injury. This is attempted under general anaesthesia in operating room with cardiothoracic surgeons present and aware of the procedure, because of the proximity of vital structures [23,24,61].

Different techniques have been described but are seldom successful if applied more than 48 h after dislocation has taken place [17]. The abduction traction technique [20] is the most effective procedure and should be done with the patient in a prone position with a sandbag between the shoulder blades. Progressive flexion and traction on the abducted arm are applied and, if this is not sufficient for reduction, the clavicle is grasped with a sterile towel clip to apply direct anterior traction. The reduction is confirmed with audible or palpable click. The adduction traction technique has been described in which traction is applied to the arm in adduction, while a downward pressure is exerted on the shoulders [21,44]. Other investigators have put a knee between the shoulders of the seated patient and, by pulling back on both shoulders, have accomplished a reduction. Often, PSCD and posterior sternoclavicular epiphyseal fracture-dislocation tend to be stable once reduced [19,53].

Open reduction and internal fixation is typically reserved if closed reduction is unsuccessful or if subluxation persists [5,8,14,16,18]. Open reduction is also recommended after 7–10 days by some authors [38,41,42], because adhesions between medial end of the clavicle to the mediastinal structures may form during this time. This is not an operation to be taken lightly, as great care is needed to avoid damage to important structures and the majority of surgeons like to have cardiothoracic team on side before starting such procedures.

Various stabilisation techniques have been described in the literature, using hardware devices, soft-tissue reconstruction with tendon graft or fascia lata flap, synthetic ligament and bone sutures. But the optimal method of stabilisation has not yet been established. However, fixation with Kirschner wires or Steinmann pins have the potential for migration towards vital structures with catastrophic complications [20,62–68] and are therefore not recommended. The use of a basler-plate seems an interesting alternative and permits early movement, but requires the removal of the plate at 3 months to prevent dislocations of the hook or widening of the insertion point in the manubrium. Introduction of the hook into the manubrium can damage the epiphyseal plate in growing children and the SCJ, risking subsequent arthrosis.

According to some authors [5,7,8,22], we have opted for suture stabilisation technique by employing bone-to-bone fixation that is safe and effective. The goal is to protect on the one hand the periosteal repair in cases of medial clavicular ephyseal fracture-dislocations and on the other hand the costoclavicular and sternoclavicular ligament repairs in cases of SCJ dislocations. The integrity of costoclavicular ligament and periosteum is crucial to prevent instability in all instances. In case of residual posterior instability, we advocate use of additional ligamentous repair through local ligamentoplasty by mean of subclavius [69] or sternocleidomastoid tendon [70].

Postoperatively, the shoulder should be held back with a figure-of-eight dressing for 4–6 weeks to allow ligament healing. A graduated progressive functional rehabilitation programme is recommended with an aim to return to sport in 3–6 months.

6. Conclusion

PSCD and posteriorly ephyseal fracture of the medial clavicle should be always considered in a young trauma patient with pain, swelling, or deformity over the SCJ. On account of the potential for serious complications with vital mediastinal structures, a prompt diagnosis and treatment are required. Despite normal radiography, a CT scan should be obtained in all cases, with suspicion of medial clavicular injury, to confirm and define the exact pattern of injury. If closed reduction fails, we recommend open anatomical reduction and internal fixation by bone suture material associated with periosteum and ligament repairs.

Conflict of interest statement

The authors report no conflict of interests.

References

[1] Stewart DP, Van Klompenberg LH. Posterior dislocation of the clavicle at the sternoclavicular joint. Am J Emerg Med 2008;26(108):E3–4.
[2] Cope R. Dislocations of the sternoclavicular joint. Skeletal Radiol 1993;22:233–8.
[3] Bennett AN, Edwards E, Kiss Z, Brukner P. Posterior sternoclavicular joint dislocation with brachiocephalic vein compression in an elite hockey player. Injury Extra 2006;37:422–4.
[4] Deganello A, Meacock L, Tavakkolizadeh A. The value of ultrasound in assessing displacement of a medial clavicular physeal separation in an adolescent. Skeletal Radiol 2012;41:857–60.
[5] Carmichael KD, Longo A, Lick S, Swischuk L. Posterior sternoclavicular epiphyseal fracture-dislocation with delayed diagnosis. Skeletal Radiol 2006;35:608–12.
[6] Beecroft M, Sherman S. Posterior displacement of a proximal epiphyseal clavicle fracture. J Emerg Med 2007;33:245–8.
[7] Thomas DP, Davies A, Hoddinott HC. Posterior sternoclavicular dislocations – a diagnosis easily missed. Ann R Coll Surg England 1999;81:201–4.
[8] Waters P, Bae D, Kadiyala R. Short-term outcomes after surgical treatment of traumatic posterior sternoclavicular fracture-dislocations in children and adolescents. J Pediatr Orthop 2003;23:464–9.
[9] Salgado R, Ghysen D. Post-traumatic posterior sternoclavicular dislocation: case report and review of the literature. Emerg Radiol 2002;9:323–5.
[10] Chaudhry FA, Killampalli VV, Chowdhry M. Posterior dislocation of the sternoclavicular joint in a young rugby player. Acta Orthop Traumatol Turc 2011;45:10–2.
[11] Buckley BJ, Hayden SR. Posterior sternoclavicular dislocation. J Emerg Med 2008;34:331–2.
[12] Mirza A, Alam K, Ali A. Posterior sternoclavicular dislocation in a rugby player as a cause of silent vascular compromise: a case report. Br J Sports Med 2005;39:E28.

[13] Leighton R, Buhr A, Sinclair A. Posterior sternoclavicular dislocations. J Emerg Med 1986;40:E53–4.
[14] Franck WM, Siassi RM, Hennig FF. Treatment of posterior epiphyseal disruption of the medial clavicle with a modified Balser plate. J Trauma 2003; 55:966–8.
[15] Winter J, Sterner S, Maurer D, Varecka T, Zarzycki M. Retrosternal epiphyseal disruption of medial clavicle: case and review in children. J Emerg Med 1989;7:9–13.
[16] Garg S, Alshameeri Za, Wallace WA. Posterior sternoclavicular joint dislocation in a child: a case report with review of literature. J Shoulder Elbow Surg 2012;21:E11–6.
[17] Gobet R, Meuli M, Altermatt S, Jenni V, Willi U. Medial clavicular epiphysiolysis in children: the so-called sterno-clavicular dislocation. Emerg Radiol 2004;10:252–5.
[18] Yang J, Al-Etani H, Letts M. Diagnosis and treatment of posterior sternoclavicular joint dislocations in children. Am J Orthop (Belle Mead NJ) 1996;25:565–9.
[19] Gilot GJ, Wirth MA. RCI injuries to the sternoclavicular joint. In: Gilot GJ, Wirth MA, Rockwood Jr CA, editors. 36 Injurie. 6th ed, Philadelphia: Lippincott William & Wilkins; 2006. p. 1363–97.
[20] Groh G, Wirth M, Rockwood C. Treatment of traumatic posterior sternoclavicular dislocations. J Shoulder Elbow Surg 2011;20:107–13.
[21] Laffosse J-M, Espié A, Bonnevialle N, Mansat P, Tricoire JL, Bonnevialle P, et al. Posterior dislocation of the sternoclavicular joint and epiphyseal disruption of the medial clavicle with posterior displacement in sports participants. J Bone Joint Surg Br 2010;92:103–9.
[22] Asplund C, Pollard ME. Posterior sternoclavicular joint dislocation in a wrestler. Mil Med 2004;169:134–6.
[23] Siddiqui AA, Turner SM. Posterior sternoclavicular joint dislocation: the value of intra-operative ultrasound. Injury 2003;34:448–53.
[24] Fenig M, Lowman R, Thompson BP, Shayne PH. Fatal posterior sternoclavicular joint dislocation due to occult trauma. Am J Emerg Med 2010;28(385.):E5–8.
[25] Ono K, Inagawa H, Kiyota K, Terada T, Suzuki S, Maekawa K. Posterior dislocation of the sternoclavicular joint with obstruction of the innominate vein: case report. J Trauma 1998;44:381–3.
[26] Wasylenko MJ, Busse EF. Posterior dislocation of the clavicle causing fatal tracheoesophageal fistula. Can J Surg 1981;24:626–7.
[27] Jain S, Monbaliu D, Thompson JF. Thoracic outlet syndrome caused by chronic retrosternal dislocation of the clavicle. Successful treatment by transaxillary resection of the first rib. J Bone Joint Surg Br 2002;84:116–8.
[28] Nakayama E, Tanaka T, Noguchi T. Tracheal stenosis caused by retrosternal dislocation of the right clavicle. Ann Thorac Surg 2007;83:685–7.
[29] Jougon JB, Lepront DJ, Dromer CE. Posterior dislocation of the sternoclavicular joint leading to mediastinal compression. Ann Thorac Surg 1996;61:711–3.
[30] Kang TL, Dudick C, Ashiku S, Baker C. Blunt rupture of the subclavian-innominate venous junction: case report and review of literature. J Trauma 2009; 66:1728–30.
[31] O'Connor PA, Nölke L, O'Donnell A, Lingham KM. Retrosternal dislocation of the clavicle associated with a traumatic pneumothorax. Interact Cardiovasc Thorac Surg 2003;2:9–11.
[32] Bucholz RW, Heckman JD. Rockwood and Green's fractures in adults (2 Volume Set). 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2001 2512.
[33] Rayan GM. Compression brachial plexopathy caused by chronic posterior dislocation of the sternoclavicular joint. J Okla State Med Assoc 1994;87:7–9.
[34] Sir Cooper A. A treatise on dislocations and on fractures of the joints: fractures of the neck of the thigh-bone. 1823. Clin Orthop Relat Res 2007;458:6–7.
[35] Rajaratnam S, Kerins M, Apthorp L. Posterior dislocation of the sternoclavicular joint: a case report and review of the clinical anatomy of the region. Clin Anat 2002;111:108–11.
[36] Brinker MR, Bartz RL, Reardon PR, Reardon MJ. A method for open reduction and internal fixation of the unstable posterior sternoclavicular joint dislocation. J Orthop Trauma 1997;11:378–81.
[37] Medvecky MJ, Zuckerman JD. Sternoclavicular joint injuries and disorders. Instr Course Lect 2000;49:397–406.
[38] Garretson RB, Williams GR. Clinical evaluation of injuries to the acromioclavicular and sternoclavicular joints. Clin Sports Med 2003;22:239–54.
[39] Hidalgo Ovejero AM, García Mata S, Sanchez Villares JJ, Martínez de Morentin J, Martínez Grande M. Posterior sternoclavicular dislocation. Report of two cases. Acta Orthop Belg 2003;69:188–92.
[40] Wirth M, Rockwood C. Acute and chronic traumatic injuries of the sternoclavicular joint. J Am Acad Orthop Surg 1996;4:268–78.
[41] Bishop JY, Flatow EL. Pediatric shoulder trauma. Clin Orthop Related Res 2005;4:1–8.
[42] Lampasi M, Bochicchio V, Bettuzzi C, Donzelli O. Sternoclavicular physeal fracture associated with adjacent clavicle fracture in a 14-year-old boy: a case report and literature review. Knee Surg Sports Traumatol Arthrosc 2008; 16:699–702.
[43] Sykes JA, Ezetendu C, Sivitz A, Lee Jr. J, Desai H, Norton K, et al. Posterior dislocation of sternoclavicular joint encroaching on ipsilateral vessels in 2 pediatric patients. Pediatr Emerg Care 2011;27:327–30.
[44] Wettstein M, Borens O, Garofalo R. Anterior subluxation after reduction of a posterior traumatic sterno-clavicular dislocation: a case report and a review of the literature. Knee Surg Sports Traumatol Arthrosc 2004;12:453–6.
[45] Wickiewicz TL. Acromioclavicular and sternoclavicular joint injuries. Clin Sports Med 1983;2:429–38.
[46] Jaggard MKJ, Gupte CM, Gulati V, Reilly P. A comprehensive review of trauma and disruption to the sternoclavicular joint with the proposal of a new classification system. J Trauma 2009;66:576–84.
[47] Echlin PS, Michaelson JE. Adolescent butterfly swimmer with bilateral subluxing sternoclavicular joints. Br J Sports Med 2006;40:E12.
[48] Martin SD, Altchek D, Erlanger S. Atraumatic posterior dislocation of the sternoclavicular joint. A case report and literature review. Clin Orthop Relat Res 1993;15:9–64.
[49] Kayias EH, Drosos GI, Anagnostopoulou GA. Atraumatic retrosternal dislocation of the clavicle. Acta Orthop Belg 2004;70:273–5.
[50] Martínez A, Rodríguez A, González G, Herrera A, Domingo J. Atraumatic spontaneous posterior subluxation of the sternoclavicular joint. Arch Orthop Trauma Surg 1999;119:344–6.
[51] Jacob M, Snashall J. X-ray-negative posterior sternoclavicular dislocation after minor trauma. Am J Emerg Med 2012;31(260):E3–5.
[52] Yeh GL, Williams GR. Conservative management of sternoclavicular injuries. Orthop Clin North Am 2000;31:189–203.
[53] Gove N, Ebraheim NA, Glass E. Posterior sternoclavicular dislocations: a review of management and complications. Am J Orthop (Belle Mead NJ) 2006; 35:132–6.
[54] Pensy R, Eglseder W. Posterior sternoclavicular fracture-dislocation: a case report and novel treatment method. J Shoulder Elbow Surg 2010;19:E5–8.
[55] Hobbs DW. Sternoclavicular joint: a new axial radiographic view. Radiology 1968;90:801.
[56] Moore T, Watkins G. Radiographic demonstration of the dislocated SC joint. Radiogr Today 1991;57:13–4.
[57] Worman LW, Leagus C. Intrathoracic injury following retrosternal dislocation of the clavicle. J Trauma 1967;7:416–23.
[58] Rudzki JR, Matava MJ, Paletta GA. Complications of treatment of acromioclavicular and sternoclavicular joint injuries. Clin Sports Med 2003;22:387–405.
[59] Lemos MJ, Tolo ET. Complications of the treatment of the acromioclavicular and sternoclavicular joint injuries, including instability. Clin Sports Med 2003;22:371–85.
[60] Bicos J, Nicholson GP. Treatment and results of sternoclavicular joint injuries. Clin Sports Med 2003;22:359–70.
[61] Selesnick FH, Jablon M, Frank C, Post M. Retrosternal dislocation of the clavicle. Report of four cases. J Bone Joint Surg Am 1984;66:287–91.
[62] McCaughan JS, Miller PR. Migration of Steinmann pin from shoulder to lung. JAMA 1969;207:1917.
[63] Lyons FA, Rockwood CA. Migration of pins used in operations on the shoulder. J Bone Joint Surg Am 1990;72:1262–7.
[64] Smolle-Juettner FM, Hofer PH, Pinter H, Friehs G, Szyskowitz R. Intracardiac malpositioning of a sternoclavicular fixation wire. J Orthop Trauma 1992; 6:102–5.
[65] Leonard JW, Gifford RW. Migration of a Kirschner wire from the clavicle into the pulmonary artery. Am J Cardiol 1965;16:598–600.
[66] Glass ER, Thompson JD, Cole PA, Gause TM, Altman GT. Treatment of sternoclavicular joint dislocations: a systematic review of 251 dislocations in 24 case series. J Trauma 2011;70:1294–8.
[67] Clark RL, Milgram JW, Yawn DH. Fatal aortic perforation and cardiac tamponade due to a Kirschner wire migrating from the right sternoclavicular joint. South Med J 1974;67:316–8.
[68] Gerlach D, Wemhöner SR, Ogbuihi S. 2 Cases of pericardial tamponade caused by migration of fracture wires from the sternoclavicular joint. Z Rechtsmed 1984;93:53–60.
[69] Burrows HJ. Tenodesis of subclavius in the treatment of recurrent dislocation of the sterno-clavicular joint. J Bone Joint Surg Br 1951;33B:240–3.
[70] Armstrong AL, Dias JJ. Reconstruction for instability of the sternoclavicular joint using the tendon of the sternocleidomastoid muscle. J Bone Joint Surg Br 2008;90:610–3.